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THE COTTON BOLLWORM:

A Summary of its Life History and Habits, with Some Results of Investigations in 1905 and 1906.

BY

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LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., February 26, 1907.

SIR: I have the honor to transmit herewith the manuscript of an account of the cotton bollworm, by F. C. Bishopp and C. R. Jones, of this Bureau, based on investigations conducted during the years 1905 and 1906, and to recommend its publication as a Farmers' Bulletin. The investigations are in continuation of those reported for the years 1903 and 1904 and published as Farmers' Bulletins 191 and 212 and Bulletin No. 50 of the Bureau of Entomology.

Respectfully,

L. O. HOWARD,
Entomologist and Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE COTTON BOLLWORM.

INTRODUCTION.

The cotton bollworm (*Heliothis obsoleta* Fab.) is one of the oldest, most widely distributed, and most destructive of injurious insects. Its presence has long been felt by cotton planters throughout the South, and since about 1850 much attention has been devoted to it by entomologists.

The more important results of the earlier investigations conducted by the General Government were published in the Agricultural Reports of the Patent Office for 1854 and 1855, in Comstock's Report on Cotton Insects (1879), and in the Fourth Report of the United States Entomological Commission (1885). More recently Bulletins 24 and 29 (old series) of the Division of Entomology were issued in 1891 and 1893, respectively, as the result of supplementary investigations. In 1896 Dr. L. O. Howard gave a very comprehensive account of this species in Bulletin 33, Office of Experiment Stations, which was later revised and made available for general distribution as Farmers' Bulletin 47.

Since 1903 Congress has provided for a continuous investigation of the bollworm, on account of the serious injury inflicted by it in the western portion of the cotton belt during the past few years. The results of this investigation have been published in Farmers' Bulletins 191 (1904) and 212 (1905); and in Bulletin 50 (new series) of the Bureau of Entomology, in which Messrs. A. L. Quaintance and C. T. Brues give a very complete and concise account of the insect to date.

The dissemination of knowledge resulting from the general distribution of the several publications upon the life history, habits, and best means of control has not been entirely void of results. Nevertheless the great majority of planters have allowed its ravages to continue unchecked from year to year.

The crisis in cotton culture in Texas, brought about by the introduction and spread of the well-known cotton boll weevil, has awakened the planters to the importance of reducing injury by other cotton pests, in order to better their chances of securing a fair crop of cotton in spite of the presence of the boll weevil. Fortunately the methods found to be of most value in boll weevil control and those which are being largely adopted throughout the weevil-infested area of Texas are also of paramount importance in lessening bollworm ravages.

LIFE CYCLE.

There are four distinct stages in the life cycle of the bollworm, as is the case with all butterflies and moths—namely, the egg, larva, pupa, and adult.

The egg.—The eggs of the bollworm moths are deposited upon various plants and other objects, mainly, however, on the favorite food plants of the larvæ—corn, cotton, and less frequently on tomatoes and tobacco. They are quite small (about one-fiftieth of an inch in diameter), whitish objects, and may usually be seen in numbers on fresh corn silks or scattered about on the leaves of corn or upon the foliage and fruit of cotton, though in the latter instances they are less easily seen, owing to their pale color. The accompanying figure (fig. 1) shows the peculiar sculpturing of the egg surface as seen with the aid of a magnifier.

The number of eggs laid by a single moth varies from about 300 to nearly 3,000, with an average of about 1,100.

The temperature has a decided influence upon the length of the egg stage. It varies from two and one-half days during the summer months to eight days or even longer in the spring and fall.

FIG. 1.—Egg of bollworm; side and top views. Highly magnified (from Quaintance and Brues).

The larva.—The larva is the destructive stage of the insect and, of course, the one most generally noticed. When first hatched it is very small and is usually overlooked until its injury to the plant upon which the egg was placed becomes severe enough to attract attention. This early period in the growth of the larva is practically the only time when it may be destroyed by the use of poisons. The period of growth of the larva is largely dependent upon temperature and the abundance of the food supply. The average length of this stage, in the summer months, is about sixteen days. During this short period the larva grows from a tiny object three-fiftieths of an inch in length to a stout worm 1¼ to 1½ inches long. There is a decided variation in the color and markings of different individuals, nearly every gradation occurring from a pale green through rose color and brown to almost black.

The pupa.—When the larva has completed its growth it leaves its food plant, usually attempting to reach the ground by crawling; it then selects a suitable spot, usually within 2 feet of the base of the plant from which it crawled or fell, and burrows from 2 to 5 inches into the soil. A cell is then constructed running back to within from one-fourth to one-half an inch of the soil surface. This provision is made so that the moth may easily push off the cap of the cell and escape. When this cell is complete the larva molts its

skin at the bottom where the burrow is somewhat enlarged, and there enters the pupal or resting stage. The accompanying figure (fig. 2) illustrates the general form of a cell, with the pupa in its normal position.

As is the case with the egg and larval stages, the pupal stage is shortest during the summer months, usually lasting from twelve to sixteen days. The insect passes the winter as a pupa.

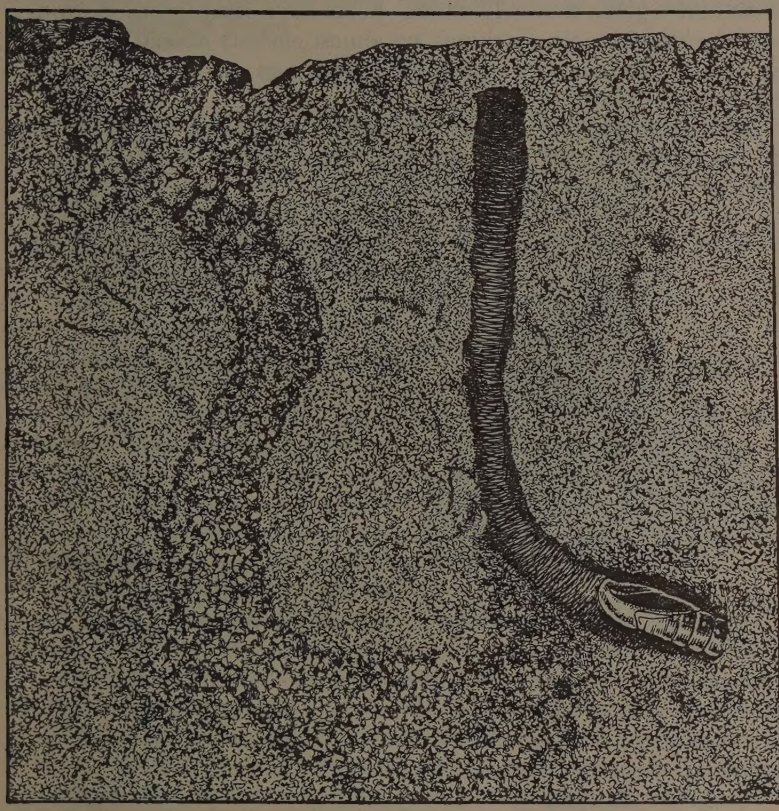

FIG. 2.—Vertical section through the soil, showing pupa of bollworm in its burrow. (Copied from Quaintance and Brues.)

The fact that the adult is unable to make its escape when the pupa is buried under a few inches of dirt and that the pupa itself is killed by undue exposure immediately suggests the importance of fall and winter plowing so as to destroy these cells and thus expose the pupæ to the inclemencies of the winter weather and to destruction by birds and other enemies. This phase of the subject will be discussed later within these pages.

The pupa is nearly four-fifths of an inch long, shining, and of a reddish brown color.

The adult.—The bollworm moth, though very readily seen in corn or cotton fields, is recognized by but few planters as the parent of the bollworm. The accompanying figure (fig. 3) may aid in its recognition.

The moths vary considerably in color and markings, ranging from a dull olive green to nearly white. Some have conspicuous markings, while with others the markings are almost entirely absent. The body is about three-quarters of an inch long, and the wing expanse is about 1⅜ inches.

During daytime the moths are seldom seen flying about, but late in the afternoon they come out from their hiding places among the foliage to seek food and deposit their eggs. It may be remarked here that the adults are capable of taking liquid food only. During the latter part of the summer this consists mainly of nectar secreted by the cotton plants. The moths are also very fond of the nectar secreted by cowpeas and when the latter are present the moths will leave the cotton fields to gather food from this source. It was found, from a large series of experiments conducted by Mr. A. A. Girault during the investigations of 1904, that the length of life of the moths depends largely upon the food supply. This also greatly influences the number of eggs deposited. In the experiments referred to above, where no food whatever was given the moths the average length of life was five and one-fourth days, and where sirup was given each day it was twenty-three and two-thirds days.

FIG. 3.—Bollworm moth in natural position, wings folded. About twice natural size (from Quaintance).

Length of life cycle.—The life cycle, from the deposition of the egg to the emergence of the moth, is completed in about thirty days during the summer months.

FOOD PLANTS.

The bollworm is practically omnivorous. Its habit of very general feeding is among the difficulties experienced in attempting its control. The plants upon which the larvæ have been known to feed number about 70. The principal crops in the United States depredated upon

by this species are cotton, corn, tomatoes, tobacco, and various garden crops.

Various names have been applied to this insect according to the food plant or character of injury inflicted, the names "bud worm," "corn-ear worm," "tomato fruit-worm," etc., being variously applied. The term "sharpshooter," being very loosely used, is quite often applied to it. The exclusive use of the term "bollworm" should be encouraged to prevent confusion, regardless of the food plant upon which the insect is found.

SEASONAL HISTORY.

As has been stated, the winter is passed in the pupal stage in cells formed in the ground for that purpose. In the spring the moths emerge at a time varying considerably in different individuals and latitudes. In southern Texas, in the latitude of Victoria, the majority of the adults emerge early in April, and in northern Texas, in the latitude of Paris, about the middle of May. At Dallas, Tex., the date of the main emergence seems to be but little earlier than at Paris. Of course the time of the first as well as the maximum appearance of bollworm moths of the first generation depends largely upon the spring temperatures.

Soon after emergence in the spring the moths fly about to find suitable places for egg deposition, the great majority of them ovipositing upon the leaves of the young field corn, which is usually about 1 or 2 feet high at this time. Upon hatching, the young larvæ feed on the corn leaves, usually eating into the roll of tender leaves at the growing tip. This produces the characteristic shot-holed appearance in the leaves as they unfold.

By the time the second generation of moths appears, the corn is coming into silk and tassel and the eggs are deposited in numbers on the silks and tassels, as well as upon the leaves. This is the most destructive generation upon corn, the ears being largely attacked. The larvæ of this generation pupate about the time the ears begin to harden, so that when the moths of the third generation appear, about two weeks later, the corn ears are nearly all hard and consequently unfit for food for the young larvæ of the ensuing brood. Finding the corn hard and dry the moths are attracted to adjacent cotton fields, where most of the eggs are deposited; from these issues the destructive August generation of larvæ, which is the main source of injury to the cotton crop. Corn is by far the most preferred food of bollworms, hence if they can find late corn in the neighborhood the moths oviposit upon it rather than upon cotton.

Injury from the fourth generation is rarely serious, as the numbers of this generation are greatly reduced by parasites and unfavorable

weather conditions. The larvæ of this brood are often quite numerous on alfalfa and in a few instances do serious damage to very late cotton and corn. The larvæ of this generation usually form somewhat deeper cells than those occurring earlier in the season and for the most part they pass the winter as pupæ. However, a few moths may emerge, giving rise to the larvæ found in very late corn and gardens up to the time of heavy frosts. The number of annual generations varies in the cotton belt from four to six according to the latitude.

EXTENT OF INJURY.

Severe injury to cotton is confined largely to the western portion of the cotton belt. During the past few years Texas has suffered by far the greatest loss of any State from bollworm ravages. Yet the losses due to bollworm depredations in Louisiana, Indian Territory, Oklahoma, Mississippi, and Arkansas are by no means small.

A combination of circumstances in the western portion of the cotton-growing area has resulted in theoretically almost perfect conditions for bollworm development. The great increase in the cotton acreage during the past few years has been due largely to the development of lands west of the Mississippi on account of the westward tide of immigration. Central and northern Texas have afforded a vast practically unbroken area of cotton and the people in general have looked upon cotton and corn as the only crops to be successfully grown on a large scale. Hence the valuable practice of crop rotation has been sadly neglected. Insufficient cultivation, due in part to the tenant system so generally employed upon the large plantations in Texas, and to the planting of an acreage of cotton too great for the working force, and also the continued planting of run-down seed without regard to earliness, prolificacy, or quality of staple, have each lent their unfortunate influence in increasing the seriousness of the bollworm problem.

The average annual injury by the bollworm to the cotton crop of the United States is probably in the neighborhood of $12,000,000.

INJURY, 1903–1906.

As has been pointed out, the extent of injury to cotton varies greatly from year to year. From a study of conditions during the past few years it appears that this depends mainly upon the relative earliness of the cotton crop, together with weather conditions. The amount of plowing done during the preceding fall and winter also exerts a decided influence upon the extent of injury.

During 1903 the cotton crop was exceptionally late; owing to adverse weather conditions during the preceding fall and winter

practically no plowing was done; the weather conditions during the latter part of the summer were favorable for bollworm increase; as a result, a year of severe and widespread depredations was experienced. Conditions in 1904 were almost the reverse and injury was much less general and less severe. The crop was planted very early, this being due in part to the fact that weather conditions during the fall and winter of 1903 permitted general plowing and preparations for planting. The winter plowing evidently resulted in the destruction of many pupæ, so that the moths emerging in the spring, as well as subsequent broods, were greatly lessened. On account of the decided earliness of the crop a considerable number of bolls were sufficiently mature to escape injury in the presence of an abundance of young bolls and squares.

During 1905 conditions were again favorable for bollworm depredations, and quite heavy losses were experienced in many counties in Texas, Indian Territory, and Louisiana. For some unknown reason little preparation was made in the fall of 1904 for planting during the following spring. The severe weather in February, followed by a wet spring, especially in northern Texas and Louisiana, resulted in general late planting throughout that section. Many heavy rains in the early summer, especially in northeastern Texas and western Louisiana, resulted in the very poor cultivation of most crops, and the complete abandonment of many fields.

While severe bollworm injury to cotton occurred over a considerable area of Texas and Indian Territory during the season of 1906, the total loss due to the pest was not so great as that inflicted in 1905.

Contrary to usual conditions the counties of extreme northeastern Texas did not suffer severe injury. The area of greatest damage extended throughout the two northern tiers of counties of Texas, from Lamar and Delta to Clay and Jack counties, and included the southwestern portion of Chickasaw Nation and the southern part of Choctaw Nation, Indian Territory. The loss to cotton growers in this area varied from 10 to 65 per cent of the crop, and in certain late-planted tracts the destruction of the crop was so complete as to render it unprofitable to even pick over the fields.

The precipitation in this section during July and August was considerably greater than normal and this condition was undoubtedly accountable, in part at least, for the greater loss occasioned by the bollworm.

In the following table a comparison is made of the cotton crop for each of the years 1903 to 1906, inclusive, in those eight counties of Texas in which exceptionally severe bollworm injury was inflicted during the year 1906.

The annual crop is given for these eight counties, taken collectively,

as also its percentage of the total crop of Texas for each year. The figures used in all cases are the number of bales ginned to December 13 of each year as given by the Census Bureau.

TABLE I.—*Comparison of the cotton crop of eight counties in Texas for the years 1903–1906.*

County.	Number of bales, 1906.	Number of bales, 1905.	Number of bales, 1904.	Number of bales, 1903.
Collin	46,902	31,035	85,128	55,995
Cooke	17,018	18,910	28,048	17,887
Denton	25,176	26,066	46,456	31,778
Fannin	57,241	35,887	81,031	40,314
Grayson	31,063	31,807	81,878	48,770
Hunt	54,186	27,359	66,658	45,458
Montague	30,568	30,069	36,270	27,370
Wise	32,304	32,320	40,181	30,014
Total for eight counties given above	294,458	233,453	465,650	297,581
Total for Texas	3,486,365	2,172,881	2,953,067	2,171,088
Percentage of Texas crop grown in eight counties given above	8.44	10.74	15.77	13.71

It is notable that the crop produced in these eight counties of Texas in 1906 constitutes but 8.44 per cent of the total crop of the State, while in 1904—a year of comparatively slight bollworm injury—the crop of this area was 15.77 per cent of the State's production. In 1903, a year of unusually heavy bollworm injury, the area under discussion produced 13.71 per cent of the crop of Texas. This comparatively large percentage may be explained by the fact that severe bollworm injury was more general during that year, and less severe in this section than in those counties in the extreme northeastern part of the State. The reduction of the total crop of Texas by the ravages of the boll weevil in 1903 also caused the percentage of the crop grown in these northern counties to appear larger, while in 1906 the crop produced in other parts of the State was exceptionally large, thus correspondingly reducing the percentage of the crop produced in this area of heavy bollworm damage.

The accompanying diagram (fig. 4) shows the approximate area of bollworm injury to cotton in Texas, Indian Territory, and Oklahoma during 1906.

MEANS OF CONTROL.

The control of the bollworm as compared with many insects presents unusual difficulties. However, as in the case of most insects, a careful study of its life history and habits has revealed certain facts which, if taken advantage of, render control quite certain.

CULTURAL METHODS.

Some planters seem to have gained the idea that when cultural methods are spoken of reference is being made to some complicated

and impractical system of cotton growing. This erroneous idea has been largely dispelled by the distribution of publications upon this subject and by the demonstration work conducted by the Bureau of Entomology during the boll weevil and bollworm investigations.

The influence of unscientific methods of farming upon insect depredations has been repeatedly shown. In the case of the bollworm, as with many other insects, it has been found from experiments con-

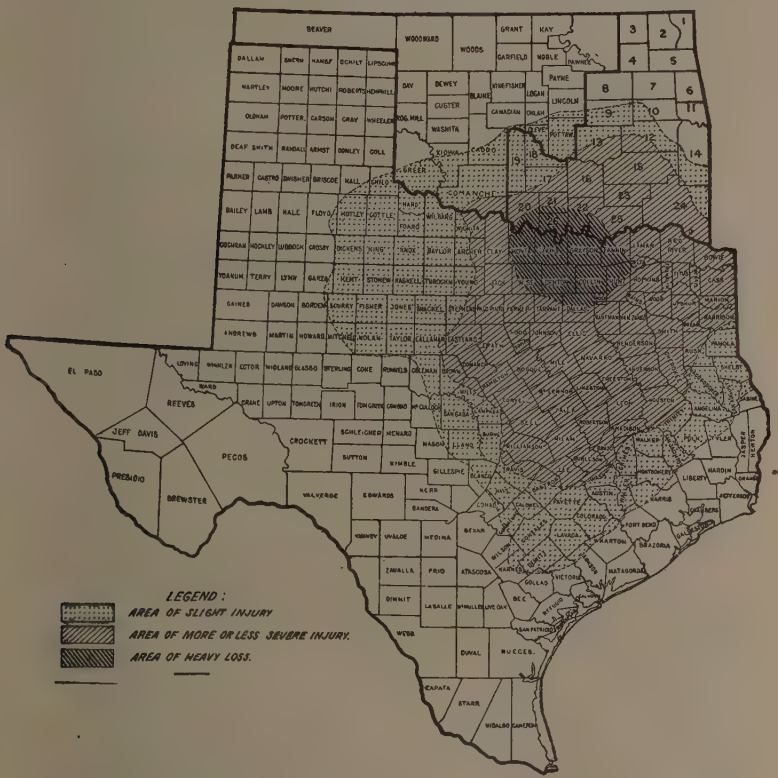

FIG. 4.—Area of bollworm injury in Texas, Indian Territory, and Oklahoma in 1906.

ducted during the past few years that much success attends the adoption of improved farm methods, such as:

(1) The planting of early maturing varieties.
(2) Early planting in the spring.
(3) The use of fertilizers.
(4) Early and thorough cultivation.
(5) The plowing in the fall or winter of all land likely to contain hibernating pupæ.

In short, any farm operation which will tend to hasten fruit production and its maturity is of value. Numerous observations indicate that bolls which are three-quarters grown or more by August 1 are practically exempt from bollworm injury; in fact, it is admitted by all that early cotton is much less subjected to injury than late cotton. This is due to the preference of bollworms for the more succulent young plants and fruit. As has been stated, few bollworms attack cotton until the appearance of the third generation, about August 1; the importance of having fruit production well advanced at this date is therefore quite evident.

The planting of cotton early in the spring is practically the only operation, valuable in reducing bollworm injury, which has received general attention by planters. The advantage gained by this desirable practice is often offset, to a great extent, by the use of "rundown" seed. Oftentimes planters fully appreciate the advisability of early planting, but are unable to carry it out owing to the fact that the land has not been prepared during the fall and winter. Many delay their planting in the spring so as to be sure that all danger from frost is past. On the whole, the gains made by early planting year after year entirely eclipse the occasional losses from late frosts.

It has been amply proved that the use of fertilizers on many Texas, Louisiana, and Indian Territory soils aids greatly in securing early maturity of cotton, as well as in increasing the yield.

The allowance of ample room between the rows and the practice of early chopping so as to encourage branching close to the ground have been found valuable in increasing early square production, and the consequent early maturity of bolls. Early and frequent cultivation should also be practiced to aid in the conservation of the moisture necessary to dissolve plant food in the soil and thus hasten the growth.

In all cases the crop should be gathered as expeditiously as possible, so as to allow the land to be thoroughly plowed during the fall and winter. As has been stated, the destruction of the hibernating pupæ may be largely accomplished by this practice and, in consequence, the succeeding generations of bollworms greatly reduced. Winter preparation of the land is, of course, a requisite for early planting as well.

ARSENICAL POISONS.

In order that a thorough understanding may be had of the use of arsenical poisons against bollworms, it will be necessary to outline briefly the habits of the adults and larvæ in cotton fields.

From numerous observations made upon the egg-laying habits of the moths during the past three years it has been determined

that from 60 to 78 per cent of the eggs deposited in cotton fields are placed elsewhere than on the squares and flowers.

Immediately upon hatching the young larva usually devours the eggshell from which it emerged. It then begins a restless search for food, wandering aimlessly about, and now and then eating a tiny portion of the epidermis of the plant. Often these actions are continued for hours, many of the delicate larvæ perishing before suitable food is found. The minute larvæ are unable to enter any but the most tender portions of the plant; consequently those hatching from the large percentage of eggs which are not placed on the tender squares, flowers, and small bolls crawl about and feed to a greater or less extent upon the surface of the plant until such portions are found.

A number of observations were made during August, 1905, upon larvæ hatching from eggs deposited on squares and flowers. The six larvæ under observation averaged about forty minutes in crawling about and feeding before the squares or flowers were entered—an ample time for them to have eaten sufficient poison to have destroyed them had these portions of the plant been thoroughly dusted with Paris green. Hence it appears, from various observations, that it would be theoretically possible to destroy about 90 per cent of the larvæ at the time of hatching, if the plants were kept continuously and thoroughly covered with Paris green. The impossibility of maintaining poison continuously upon all parts of the plants during the entire period of egg hatching is obvious. However, practical tests of poisoning cotton (see pp. 25–27) indicate that satisfactory results may be obtained by making from 1 to 3 applications of Paris green or other arsenical poison at the proper time.

No arbitrary date for the application of poison may be given on account of the variability of the time at which the larvæ begin to hatch in destructive numbers in different localities and seasons. Moths are seldom seen in cotton fields until the third generation appears, which is usually from July 20 to August 5. When moths in large numbers are seen flying about the fields in the evening it may be taken for granted that oviposition is taking place and the poison should be applied within three or four days.

As regards the dusting and spraying methods, the former is usually more practicable, owing to the difficulty often experienced in securing water in proximity to the fields and the greater time required in applying poison in liquid form.

The bag and pole method of application is fairly efficient and obviates the purchase of machinery. Geared machinery may be secured to apply poison either in the dust or spray form. The expense of

purchasing such machinery may be reduced by two or three planters buying one machine for their common use. By the use of geared machinery from 20 to 30 acres of cotton may be dusted in the few hours suitable for the work. In order to secure good results the plants should be dusted while still wet from dew or a light shower, as the moisture aids in retaining the fine particles of poison upon the foliage.

Three pounds of Paris green should be applied per acre and where large machines are used economy may be practiced by mixing the poison with from three to four times the amount of cheap flour or fine, air-slaked lime. In spraying, the poison should be used at the rate of 1 pound to 50 gallons of water. Owing to the variability in strength of poisons only reliable brands should be purchased.

The decided prejudice on the part of many planters and pickers against the application of poison is entirely unfounded, for no danger attends its proper use either in the application or in picking cotton in fields which have been treated.

TRAP CROPS.

As has been stated, corn is the preferred food of bollworm larvæ and nectar secreted by cowpeas is very attractive to the moths. From a consideration of these facts it is perfectly natural to conclude that by proper manipulation these may be made to form a trap for the bollworm and thus protect cotton or other crops from injury.

The best results may be secured by leaving several unplanted strips, from 60 to 80 feet wide, across the fields at the time of planting cotton. These strips should later be planted to corn and cowpeas in alternate rows about 3 feet apart at a time which will permit of the corn being in silk and tassel and the peas in bloom by August 1, the approximate date of the emergence of the majority of third generation moths. The early corn being then about ripe the moths are immediately attracted to the trap rows. The cowpeas afford food and hiding places for the moths and corn is the favorite plant for oviposition; the moths are therefore content to remain in the trap rows and here their eggs are concentrated, thus leaving the adjacent cotton practically free.

The accompanying table gives some idea of the number of eggs kept from surrounding cotton fields by the employment of a small area of June corn as a trap crop. These observations were made during 1905 at Ardmore, Ind. T., on a small area of corn which was in prime silking condition on August 1. At the time of the first examination the corn was in full silk and when the second examination was made the silks were largely dry and some corn in roasting ears. The figures show the average number of eggs per plant and

the average number on various portions of the plant; also the average number of larvæ per plant and their approximate sizes.

TABLE II.—*Average number of bollworm eggs and larvæ on corn trap crop.*

Date of examination.	Number of plants examined.	Average number of eggs per plant.					Average number of larvæ per plant.					
		On entire plant.	On leaves.	On sheath.	On tassel.	On silk.	All sizes.	Less than one-fourth grown.	One-fourth grown.	One-half grown.	Three-fourths grown.	Full grown.
August 1	10	414.3	103.6	42.2	71.7	196.8	3.4	2.7	.7	.....	.....	.....
18	5	168	58	11	24.4	74.6	22.3	11.8	5.4	3.2	1.8	.1

Viewing the trap-crop idea superficially it might appear that the increase of bollworms would be favored by supplying their favorite food. This, however, is not the case. The concentration of the eggs upon the corn results in their destruction in large numbers by parasites an l predaceous enemies which are attracted by the abundance of food and favorable breeding places furnished them in the form of bollworm eggs and larvæ. It is seldom that more than 1 or 2 of the 15 to 30 larvæ which usually hatch in the fresh silk of an ear of corn ever attain full growth on account of their cannibalistic habits.

The mistake of planting belts of corn through or around a cotton field at the usual time of planting corn in the spring is of quite common occurrence. Instead of this acting as a trap, as is desired, it is really detrimental, as the corn furnishes a favorable breeding place for the larvæ during the early summer and becomes hard about the 1st of August, thus forcing the moths of the third generation to seek other places for oviposition.

With favorable weather conditions and fair cultivation corn planted the last of May or 1st of June will be in silk and tassel by August 1. Cowpeas planted about ten days later will be in full bloom about that date. Mexican June corn is usually preferable for late planting, owing to its larger root system and consequent greater ability to withstand drought.

The trap-crop system will give best results if generally adopted by the farmers in each locality. On large plantations the planting of small areas of corn here and there in the fields is practicable. Such early crops as potatoes, oats, or wheat may be followed by corn and cowpeas with practically the same results.

The corn may be harvested in the usual way, and the peas either harvested or plowed under. Mention should be made of the benefit exerted upon the soil by the growing of cowpeas or other plants of this class.

FIELD WORK, 1905–1906.

Laboratory investigations of the bollworm, such as the breeding of parasites, the studying of predaceous insect enemies, etc., were carried on during the year 1905. Attention was devoted mainly, however, to field experiments and demonstrative work. As the investigating force was limited to the writers, it was found impossible at times, when the work was most pressing, to devote such personal attention to some of the experiments as was desired. Only a portion of the writers' time could be devoted to bollworm work during the year 1906, and for this reason laboratory investigations were entirely eliminated.

The bollworm investigations during the last three years have been confined principally to those portions of northern Texas and southern Indian Territory which have suffered most in recent years from bollworm depredations. The endeavor has been to locate the experiments, as far as possible, in territory not seriously infested with boll weevils, and thus avoid complications from this source in the results.

In general, the field work has been continued along lines similar to those followed in 1903 and 1904, some results of which were published in Farmers' Bulletins 191 and 212.

The following is a list of the experimental and demonstration farms established:

Experimental farms used in bollworm investigations.

1905.

Location.	Plantation of—	Number of acres.
New Boston, Tex	H. B. Eubank	48
Avery, Tex	P. B. Gibbons	40
Quinlan, Tex	R. W. Hodge	16
Do	Joe H. Smith	24
Do	W. B. Green	8
Do	G. H. Vining	12
Do	W. F. Addington	10
Do	D. F. Borden	10
Do	W. E. Smith	10
Do	W. A. Wallace	10
Do	W. Higden	10
Greenville, Tex	Capt. J. F. Nichols	40
Rosser, Tex	Geo. F. Stribling	40
Ardmore, Ind. T	W. P. Poland	20
Do	S. A. Brown	40
Atoka, Ind. T	John Wilson	12
Mound, La	Col. F. L. Maxwell	55

1906.

Denton, Tex	S. W. Kanady	24
Mineola, Tex	J. W. Bogan	10
New Boston, Tex	J. N. Glass	48
Wolfe City, Tex	C. E. Keithly	48
Do	J. C. Clement	28
Mound, La	Col. F. L. Maxwell	55
Ardmore, Ind. T	D. L. King	40

During 1905, in addition to the 405 acres mentioned, about 50 acres were used in 12 farms near Clarksville, Tex., in a cooperative test of the corn trap-crop system, and several small areas were used in cooperative work in other localities.

Upon these experimental farms an endeavor was made to demonstrate the value of the several remedial measures outlined in the preceding pages, under "Means of Control."

In all of the experiments conducted in 1905 the results, as shown by final yields, were supplemented by observations throughout the season upon the relative earliness of and comparative bollworm injury to the plats receiving various treatments. The results of these observations conform closely with the final yields and strongly emphasize the value of improved methods in protecting cotton from bollworm injury. These observations include cotton grown on the principal types of soil of northern Texas.

At the time of examination the injury to late planted cotton and to cotton raised from degenerate seed varied from 12 to 49 per cent, and to early planted cotton and cotton grown from improved seed the injury varied from 1 to 23 per cent.

To illustrate the decided preference of the bollworm for the less mature fruit, of a total of 24,292 squares and bolls examined in several localities, those one-half grown or less numbered 20,789, of which number 20.4 per cent were injured; the bolls over one-half grown numbered 3,504, with 7.2 per cent injured. The contrast between the percentages of injury would have been still greater had the examinations been made two weeks earlier, as a considerable number of the injured squares and bolls had fallen and were buried by cultivation, while the majority of the more mature fruit was retained by the plant even though badly injured.

ARDMORE FARM.

The experimental area on the farm of Mr. S. A. Brown was located on a typical sandy soil of the cross timber region and consisted of ten 4-acre plats.

The experiment consisted of comparing the King and Rowden varieties now becoming so generally adopted in the bollweevil and bollworm districts of Texas with the much later big-boll sorts from gin-run seed. The effect of commercial fertilizers upon the early maturity and total cotton production was also studied. Three standard commercial fertilizers were used in the experiment: (1) A complete fertilizer, showing by analysis 8 per cent available phosphoric acid, 2 per cent potash, and 2 per cent nitrogen; (2) a compound of acid phosphate and potash without nitrogen, the analysis of which showed 10 per cent available phosphoric acid and 4 per cent potash;

(3) acid phosphate alone, showing by analysis 14 per cent available phosphoric acid.

The following table shows the treatment given and the yield from the several plats, together with the increased yield from the use of fertilizers and improved seed, as compared with the yield of cotton from ordinary gin seed.

TABLE III.—*Treatment of and results from plats on bollworm experiment farm of U. S. Department of Agriculture, Ardmore, Ind. T., 1905.*

Plat No.	Variety of cotton.	Fertilizer, and quantity used per acre.	Date of planting.	Number of times cultivated.	Number of times hoed	Yield per acre in pounds of seed cotton.	Increase per acre in pounds of seed cotton as compared with Plat VII.	Value of increase with seed cotton at 33 cents per pound.	Cost of fertilizer per acre.	Net gain per acre.
I	King	C. B. G.,[a] 300 pounds.	Apr. 28	4	3	1,082.75	712.75	$23.25	$3.45	$20.07
II	Rowden	....do	Apr. 29	4	3	1,003.75	633.75	20.91	3.45	17.46
III	King	Unfertilized	May 1	4	3	810.75	440.75	14.54	.....	14.54
IV	Rowden	R. P. C.,[b] 300 pounds.	....do	4	3	837.50	467.50	15.42	3.23	12.19
V	King	....do	May 2	4	3	834.50	464.50	15.33	3.23	12.10
VII	Big boll (variety unknown)	Unfertilized	May 3	4	3	370.00	.....	.....	.....	.....
VIII	King	R. A. P.,[c] 300 pounds.	May 4	4	3	917.00	547.00	18.05	2.85	15.20
IX	Rowden	Unfertilized	....do	4	3	430.25	60.25	1.99	.....	1.99
X	.....do	R. A. P., 300 pounds.	May 5	4	3	749.75	379.75	12.53	2.85	9.68

[a] C. B. G.—A commercial cotton boll guano; analysis—available phosphoric acid, 8 per cent; potash, 2 per cent; nitrogen, 2 per cent.
[b] R. P. C.—A commercial potash compound; analysis—available phosphoric acid, 10 per cent; potash, 4 per cent.
[c] R. A. P.—A commercial phosphoric acid; analysis—available phosphoric acid, 14 per cent.

Table IV, which follows, shows the comparative earliness of fruit maturity on the several plats. The amount of seed cotton picked from each plat during each month is followed by the total amount picked from said plat to the end of that month.

TABLE IV.—*Comparative earliness of fruit maturity on plats on bollworm experiment farm of U. S. Department of Agriculture at Ardmore, Ind. T., 1905.*

Plat No.	Total pounds of seed cotton picked.								
	During August.	During September.	To September 30.	During October.	To October 31.	During November.	To November 30.	During December.	To December 31.
I	613	1,834	2,447	1,223	3,670	661	4,331	0	4,331
II	568	622	1,190	1,021	2,211	1,502	3,713	300	4,013
III	247	1,086	1,333	678	2,011	952	2,963	280	3,243
IV	0	916	916	821	1,737	1,303	3,040	310	3,350
V	565	1,358	1,923	821	2,744	274	3,018	320	3,338
VII	0	302	302	0	302	0	302	1,178	1,480
VIII	191	1,127	1,318	1,329	2,647	0	2,647	1,021	3,668
IX	0	303	303	533	836	0	836	885	1,721
X	0	786	786	655	1,441	836	2,277	722	2,999

From a study of the table several important points immediately present themselves. The decided earliness of fruit production upon the King plats is very noticeable. During August all of the King plats had opened a sufficient number of bolls to be picked over, while but one of the Rowden plats could be picked. The uniform earliness of the fertilized as compared with the unfertilized plats is also noticeable; for instance, on September 30 Plat I—King seed, fertilized—had produced 2,447 pounds seed cotton, while on the same date Plat III—King seed, unfertilized—had produced but 1,333 pounds. Comparing results from the use of the three different fertilizers, plats upon which the complete fertilizer was applied excelled both in earliness and total production. The average yield per acre in pounds of seed cotton was 1,043.25, 836, and 833.37 upon the plats fertilized with complete fertilizer, potash compound, and acid phosphate, respectively. The contrast in earliness and total yield in the case of Plat VIII, planted with unimproved seed and unfertilized, and the various other plats is so marked as to need no special mention.

NEW BOSTON FARMS.

Twelve plats of 4 acres each were used in the experiment conducted upon the plantation of Mr. H. B. Eubank during 1905. The soil upon which the experimental farm was located consists of a sandy loam, with a red clay admixture.

The exceedingly adverse weather conditions during the spring and early summer greatly handicapped the experiment, and resulted in a smaller yield than was anticipated; however, all circumstances considered, the results were very satisfactory.

The experiment consisted of a fertilizer test in which King, Rowden, and gin seed were used. The best results, both in earliness and total production, were obtained by using King seed, fertilized with 300 pounds of cotton-seed meal and 100 pounds of acid phosphate per acre. Almost as good returns were secured by using King seed fertilized with 100 pounds per acre of each of the following: Acid phosphate, German kainit, and nitrate of soda.

During the past season Mr. J. N. Glass conducted a similar experiment upon his plantation, which is located in the deep sandy land region south of New Boston. Owing to the comparative freedom from bollworm injury the cultural methods employed were not put to a severe test, hence the results as shown by the total yield from plats where fertilizers and improved seed were used and early planting and thorough cultivation were practiced can not be satisfactorily compared with the yields from unfertilized plats planted to gin seed

and receiving only ordinary care. In all cases there was a ready response to the application of complete fertilizers, both in earliness and increased production.

SUMMARY REMARKS CONCERNING THE USE OF FERTILIZERS.

From three or even several years of tests with fertilizers the writers would be entirely unwarranted in making other than certain general statements regarding their use. The decided variability in the soil constituents, even upon the same character of land, and the variation in weather conditions during different seasons render specific recommendations inadvisable.

Many of the Texas soils have been found to be benefited by phosphoric acid. As the chief object of these experiments has been to increase early fruit production, and as acid phosphate influences and hastens fruiting, the general plan has been to supply an abundance of this element along with the other elements in which the various soils are supposed to be deficient.

The question is still open as to whether the general use of fertilizers upon the rich bottom lands and strong, black waxy lands of northern Texas will prove of value. However, there seems to be no doubt that the application of fertilizing elements to many of the soils of northern Texas and Indian Territory will increase the earliness and prolificacy of cotton. The experiments at Ardmore, Ind. T., and New Boston, Tex., indicate that the use of complete fertilizers with a large percentage of phosphoric acid will give best results upon the sandy loam soils of those types. Experiments conducted upon the gray or mixed soils, as in the case of the plats on the farms of Mr. C. E. Keithly at Wolfe City, Tex., and Mr. S. W. Kanady at Denton, Tex., indicate that soils of this type respond freely to the application of acid phosphate. The addition of a small percentage of potash to an acid phosphate fertilizer seems also to give beneficial results. In general, fertilizers containing large percentages of nitrogen should be avoided, as they tend to produce a large and succulent growth of stalk and foliage which favors bollworm as well as bollweevil depredations. In order to secure the best results from the use of fertilizers it is necessary that the soil be kept in good physical condition.

It is to be hoped that the data obtained during the investigations of the past three years may serve as a basis for experimentation on the part of planters in various localities to determine which of the three principal elements of plant food—namely, phosphoric acid, potash, and nitrogen—and what proportions and amounts of each, will give the best results on their respective soils.

INJURY TO FIELD CORN.

The close relation between the depredations of the bollworm upon corn and cotton has necessitated a careful study of the insect in the former as well as in the latter crop. The characteristic injury to corn has been described in the preceding pages. Although bollworm injury to cotton greatly eclipses that to corn, the loss occasioned by its presence each year in probably more than 75 per cent of the corn ears and by the additional damage resulting from ferments, molds, and rain admitted through the exit holes of the larvæ is considerable.

Injury to young corn by the first brood of bollworms is seldom serious. A notable exception, however, is presented in the case of extremely severe injury inflicted upon young corn by this brood at Victoria, Tex., during the spring of 1905. Mr. W. W. Yothers, of the Bureau of Entomology, investigated this outbreak quite thoroughly during the latter part of May. It was found that severe injury had been inflicted over quite an extended area, necessitating the replanting of a considerable portion of the corn acreage to June corn or cotton. It was estimated by Mr. Yothers and others that the total yield in the vicinity of Victoria would be reduced fully 40 per cent on account of bollworm injury. Severe injury to corn was reported also in Shackleford County, Tex., but its extent was not definitely ascertained.

In 1905 numerous observations in northern Texas and Indian Territory showed the number of eggs and larvæ to be comparatively few upon corn until about July 1. After this date, however, from 90 to 100 per cent of the corn ears were found to be infested. No serious injury to corn was reported in 1906, but observations showed that practically complete infestation of corn ears was attained during the latter part of the summer.

The chief means of reducing bollworm injury to corn is by thoroughly breaking, during the fall and winter, all land likely to contain hibernating pupæ, a procedure which the writers have stated to be an important part of the cultural system in reducing bollworm injury to cotton. The practice of having children and plow hands destroy all larvæ noticed in the buds of young corn plants is commendable.

RESULTS OF POISON EXPERIMENTS.

During 1904 poison experiments were conducted at Ladonia, Paris, and Cooper, Tex. At Ladonia and Paris the experiments were conducted directly by the writers, while at Cooper the work was carried out by Mr. N. P. Robertson, of that place. The dusting method was used exclusively. The Paris green was mixed with fine, air-slaked lime at the rate of 1 pound of Paris green to 4 pounds of lime, and the

mixture applied at the rate of 15 pounds per acre. The general plan adopted in all the poison experiments was to select two areas of from 3 to 10 acres each upon which the cotton was as uniform as possible, then to apply poison to one, leaving the other as a check.

At Ladonia and Paris 24 acres were poisoned, an equal acreage being left unpoisoned as a check. A hand blower, mounted on a wagon with wheels sufficiently far apart to include between them two cotton rows, was used in these experiments, while at Cooper a geared blower was employed. Desirable results have attended the application of poison in practically every instance. The unfavorable results shown in a few cases were attributable to unevenness of stand or to a too late application of the poison.

The results of the poison experiments at Cooper are given below:

TABLE V.—*Results of experiments of the U. S. Department of Agriculture in poisoning the bollworm, at Cooper, Tex.*

On plantation of—	Number of applications.	When applied.	Area poisoned.	Area unpoisoned—check.	Yield of seed cotton from poisoned area.	Yield of seed cotton from unpoisoned area.	Gain of seed cotton per acre where poison was applied.	Value of gain at $0.0325 per pound.	Cost per acre of poison mixture.	Cost per acre of mixing and applying poison.	Net gain per acre where poison was used.
			Acres.	*Acres.*	*Lbs.*	*Lbs.*	*Lbs.*				
S. Robertson	1	Aug. 15	2½	2½	2,508	1,892	246.5	$8.00	$0.61	$0.60	$6.79
T. C. Hunter	1	Aug. 9	5½	5½	6,325	5,750	100.0	3.25	0.61	0.60	2.04
Fred Johnson	1	Aug. 11	5	5	3,964	3,546	81.6	2.65	0.61	0.60	1.44
N. P. Robertson	2	Aug. 12 Aug. 18	5¼	5¼	5,922	3,609	420.0	13.66	1.22	1.20	11.24

The above figures show a weighted net gain of $5.21 per acre upon the four poisoned areas, as compared with similar adjoining areas which were not poisoned.

The marked gain upon the plat receiving two applications was probably not due so much to its having received two applications as to the exceptionally favorable conditions attending the poisoning. The two fields showing the greatest gain per acre were smooth, so as to admit of the easy manipulation of the large machine over the entire area, while the others were more or less rough; the wind was also favorable when the former fields were treated. A slight shower preceded the second application upon the area on Mr. N. P. Robertson's farm, thus causing the poison to adhere well to the plants.

During 1905, at Quinlan, Tex., about 50 acres were used in poison experiments. In general, the results of these experiments were satisfactory. Apparently no advantage was gained by making a second

application between August 17 and 20, the first having been made between August 1 and 5.

On August 24 counts were made to determine the percentage of injury to cotton on the poisoned and unpoisoned areas on the farms of Messrs. W. A. Wallace and W. Higden. Ten typical plants were chosen in each of the poisoned and unpoisoned areas, and all fruit upon the plants and ground beneath them carefully examined. On Mr. Wallace's farm the plants on the unpoisoned plat showed that over 16 per cent of the entire fruit was injured, while only 10 per cent of fruit on plants on the poisoned plat showed injury. On Mr. Higden's farm 15 per cent of the fruit of the plants on the unpoisoned plat was found to be injured, while but 9 per cent was injured on the poisoned plat.

TRAP CROP EXPERIMENTS.

In view of the fact that the greatest benefit from the use of June corn as a trap crop will come from its general planting throughout a neighborhood, an endeavor was made during the spring of 1905 to arouse general interest in the trap-crop system among the farmers in the vicinity of Clarksville, Tex. Nearly every season bollworms are more or less destructive in this locality, hence it was deemed a desirable place for a test of this kind.

Arrangements were made with each of several planters just north of Clarksville to plant from 3 to 6 acres of June corn and cowpeas. The total area thus arranged for in the experiment was about 50 acres.

Unfortunately the abnormally heavy rains during June and early July rendered cultivation of the corn impossible. In several instances the crop was entirely killed out by the excessive rains and weed growth.

There is no way of measuring the value of a trap crop in pounds of seed cotton, as it is impossible to arrange a check plat of cotton where conditions are identical without having the plats adjacent, and in this case equal protection is afforded both of the cotton areas. Although the experiment was greatly handicapped by the above-mentioned weather conditions, numerous observations during August and September showed that the adjacent cotton was being protected to a considerable extent by the deposition of a large number of bollworm eggs on the trap corn.

At Quinlan, Tex., about 30 acres were utilized in a similar experiment, with apparently good results. In some instances, in addition to the protection afforded the adjacent cotton, a large yield of corn was obtained from the trap areas.

LOCAL EXTERMINATION.

Many insects increase with amazing rapidity from the comparatively few individuals which pass the winter successfully to the countless thousands at the close of summer. The bollworm offers a good example of this, although the increase in its case is not so striking as with some other insects.

It has been estimated by Messrs. Quaintance and Brues, from observations made during 1904, that in the third generation the larvæ resulting from one female emerging the previous spring would number 21,175; or one larva of the first generation will give rise to 683 descendants in August—a sufficient number to completely ruin 78 large cotton plants. In making these calculations due allowance was made for destruction in the different stages by various natural agencies. From these figures the importance of destroying the larvæ of the early generations is very apparent.

Experiments conducted at Quinlan, Tex., and Atoka, Ind. T., during 1905 indicate that in isolated localities almost complete freedom from bollworms in cotton may be secured by destroying the larvæ of the first and second generations in all adjacent cornfields.

Various mechanical devices have been suggested for use in destroying larvæ in corn ears. The writers have given the subject some attention, but have been unable to devise any satisfactory scheme for killing the larvæ without opening the ears by hand. When mechanical devices are used the ears are often greatly damaged and in many instances the larvæ escape.

In the experiments conducted very few larvæ of the first generation were seen in the young corn, and the fields were not carefully gone over at that time; however, nearly every ear was infested by the second brood, as is shown in the accompanying table. In case of the Mineola record, ears upon which eggs were deposited were not included in the number of those infested. Had these been included with the number of infested ears, as should have been done, the infestation would have reached about 92 per cent.

TABLE VI.—*Bollworm larvæ in corn and cost of extermination.*

Locality.	Date of extermination.	Total ears examined.	Percentage of ears infested.	Total larvæ destroyed.	Cost per acre of extermination.
Quinlan, Tex	July 25, 1905	8,615	96.1	8,706	$4.40
Atoka, Ind. T	July 29, 1905	8,279	95.7	10,924	3.54
Mineola, Tex	July 20, 1906	14,748	74.4	11,039	2.20

At Quinlan the larvæ were extracted from the ears on about 3 acres of corn and at Atoka from about 2½ acres. About 7½ acres of

corn were thus treated at Mineola. The stand, however, was poor, and therefore the number of ears per acre was comparatively small. In these experiments each ear was opened sufficiently at the tip to admit of the destruction of all larvæ with the fingers. The cost of the work was increased about one-third on account of the making of a complete record of the number of eggs upon the fresh silks and the number and approximate size of all larvæ.

For several reasons it is safe to say that the practice of destroying larvæ of the early generations in corn, however important, will never be generally adopted. In the first place it would be impossible to get concerted action in work of this kind, where immediate results can not be seen. The question of securing efficient labor at the time the work should be done, though difficult, would be no more so than that of finding time to go over large areas of corn. The practice of opening the corn ears might also be objectionable in some cases, as it would increase the danger of loss from decay and mildew during rainy seasons. The husks should be closed after removing the larvæ, so as to protect the ears from injury by birds.

At present it seems that the plan of extermination can only be profitably adopted in isolated localities and where the corn acreage is small as compared with the acreage of cotton thus protected.

Owing to the fact that the moths fly freely, entire protection to cotton can not be insured even though all larvæ are destroyed in adjoining cornfields—if there are such in the immediate neighborhood. However, where some barrier exists, such as timber or a large field of grain—the former especially—between neighboring cornfields and the area for which protection is being sought, there is little danger that moths will find their way in numbers to the cotton.

THE MORE IMPORTANT NATURAL FACTORS IN BOLLWORM CONTROL.

The feeding habits of the bollworm larvæ afford them much protection from various natural enemies. The mortality from these sources is therefore much greater in the egg stage than during any other period of development. Numerous parasitic and predaceous insects destroy a great many eggs and this is especially true where the eggs are concentrated upon certain plants, as in the case of corn used as a trap crop. A tiny parasite, scarcely visible to the unaided eye, is responsible for the destruction of from 20 to 80 per cent of the eggs laid upon corn, as well as a large percentage of those upon cotton. Numerous insects feed largely upon bollworm eggs and small larvæ; the larvæ of several ladybirds and small larvæ known as aphis lions are among those most beneficial in this respect.

The larger bollworm larvæ are preyed upon by several insects, among the more important of which are several species of wasps and ground beetles. The value of the common black and red wasps which so frequently build nests in trees and outhouses near cotton fields is unquestionable. At Paris, Tex., during 1905, a nest of the former species, located in an old cotton house with several cotton fields near by, was carefully observed for two hours. The nest consisted of about 800 cells, with about 280 adults present at one time. During the period of examination 168 wasps entered with food for their larvæ and for other adults. In 118 instances the food brought in was recognized as being bollworm larvæ. Probably the majority of the other 50 wasps carried bollworms, but identification was impossible, because the larvæ were so badly mangled.

Several large robber flies, so often seen in cotton fields, and a few species of spiders, have been known to capture bollworm moths. The common toad also is beneficial, for in several instances the writers and others have found numerous bollworm larvæ in its stomach.

There are published few records of birds feeding upon bollworms, yet there is every reason to believe that bollworm larvæ and adults are destroyed by many species. Domestic fowls are undoubtedly valuable in reducing the number of bollworms on cotton located near houses and barns. Several instances have come under the writers' observation in which cotton adjacent to barns where chickens, turkeys, and guineas were kept was practically free from bollworms, while at some distance out in the fields the injury was quite severe.

One of the most important checks upon bollworm increase is the cannibalistic habit of the larvæ themselves. After the larvæ have attained considerable size they are ever ready to engage in battle with their fellows whenever they chance to meet. When two larvæ are of unequal size the smaller is usually killed and devoured by its fellow, but if their size is about the same, both larvæ often die as a result of injuries inflicted upon each other. This factor is of greatest importance in corn, for if all of the larvæ hatching in the silks of an ear should attain full growth nearly every ear would be completely destroyed. The reduction in bollworm numbers in ears of corn, due mainly to this cause, is illustrated by the following figures: During August, 1905, 10 ears of corn were examined just after the silks began dying, and 198 larvæ in all stages of development were found. This gives an average of 20 larvæ per ear, most of which were small, or about 10 times the number which would ultimately reach maturity. Cannibalism is a less important factor among larvæ on cotton, as in that case the larvæ are more generally distributed over the plants and therefore meet less frequently.

A certain bacterial disease is worthy of note as an important natural factor in bollworm control. As a rule the disease develops among the larger larvæ and a larger percentage of larvæ usually die in corn ears than upon cotton; this is probably due to the fact that more moisture is present in the corn ears than in the small fruit of cotton where the larvæ feed. From 2 to 50 per cent of larvæ taken on corn and cotton and kept in the laboratory have been found to die of this disease. Examination of several thousand ears of corn during July showed that from 1 to 5 per cent of the larvæ found therein had succumbed to this disease.

RECOMMENDATIONS.

The investigations conducted by the Bureau of Entomology during the past three years show that by the general adoption of the several means of control herein described losses from the bollworm may be largely prevented, even during years of severe injury.

The fact that bollworms do not become numerous in cotton until the hardening of the early corn about August 1 is the basis for the recommendation of certain cultural methods not only advantageous in the presence of the bollworm and boll weevil, but desirable practices in cotton growing regardless of insect enemies. These methods are as follows:

(1) Thorough plowing of the land during the fall and winter. This operation is not only the means of destroying many bollworm pupæ, but is of importance from an agricultural standpoint, in exposing the soil to the actions of rain and frost, thus helping to break up its constituents and render them more readily dissolved and consequently available for plant food. Fall plowing is also a requisite for early planting.

(2) The use of early fruiting varieties of cotton.

(3) The use of fertilizers to hasten and increase fruit production.

(4) Planting the crop as early in the spring as practicable.

(5) Early and frequent chopping and cultivations.

Along with the improved farm practices above outlined, the cotton crop may be materially protected by the use of corn and cowpeas as a trap crop (as described on pages 18–19). That the greatest benefit may be derived from the use of the trap crop system it is urged that each farmer in a neighborhood plant at least a few acres of June corn and cowpeas about the 1st of June.

The use of arsenical poisons upon the cotton will be found of value in proportion to the severity of bollworm attack. Paris green is recommended at the rate of about 3 pounds per acre, applied in the dust form, either pure or diluted with lime or flour. Application by

either the bag and pole method or by geared machinery is satisfactory. The work should be done when the plants are moist with dew or after a light shower. Two applications, when not followed immediately by rains, should be sufficient; the first should be made when the eggs begin to hatch in numbers, usually between July 25 and August 5; this may be followed by a second in about one week. If rains follow the applications, these should be repeated immediately.

Destruction of the early generations of bollworm larvæ in corn seems impracticable, except in certain cases of isolated areas and where the acreage of corn is small as compared with that of cotton.

Owing to the great value of wasps in destroying bollworm larvæ throughout the season a protest should be made against the common practice of destroying their nests. Where domestic fowls are reared these should be encouraged to feed as much as possible in adjoining cotton.

For practical as well as other reasons wild birds should be protected and encouraged in their visits to cotton fields.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

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